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The Principles That Generate Innovative Construction Solutions

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In this research we set up principles, on which basis, with the help of the developed system algorithm of creative thinking (SACT), we obtained innovative engineering developments. This methodology has allowed discovering and elaborating new directions for scientific development in the field of building:

- *The control of constructions, including the energy aspects of realization;*
- *Construction in difficult soil conditions and seismicity;*
- *Ecological preservation of northern areas of Siberia in the process of building land reclamation;*
- *To modify the well-known cybernetic postulate which shows the connection between the system structure and the incoming current information.*

All these directions have received innovative and constructive realization in the form of series of patents of some objects of building.

Using classical concepts of creative thinking it is possible to define the elaborative methodology as a way from the general (functional) solution to the variety of definite decisions. This methodology essentially differs from the well-known approaches, particularly the theory of decision of the inventive problems and various methods of decision-making which are focused on the search of definite specific solutions. This methodology can be useful not only in the field of building, but also in other spheres of technics.

Keywords: principles, the system approach, the system algorithm of creative thinking, controlled structures.

1. Introduction

The offered technique consists of two parts. The first (general) of the rational search option contains principles that are alternative to the traditional, which implementation is illustrated by examples and opens new directions for the intermutation of constructions (systems). The second part is devoted to the innovative design

solutions, implemented on the basis of the algorithm principles, using a system of creative thinking (SACT), the essence of which is also presented in the given research.

2. The search for alternative principles

At the **first** stage of search, on the basis of the objective requirement, it is necessary to analyze

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the existing state of development of a problem, to understand the applied traditional principle (approach), the accepted restrictions and the contradictions, which demonstrate its insufficient efficiency (limitation) of adoption.

The **second** step is a definition (formulation) of an alternative principle which is free from the basic contradictions and restrictions of the traditional approach, i.e. the new principle overcomes the identified contradictions and restrictions at the **functional level** and thus predetermines the basic possibilities (effect, advantages) of its applications.

The **third** stage (step) is aimed at possible realization of an alternative principle on the basis of the system algorithm of creative thinking (SACT), i.e. search for structure in specification of the definite problem. We will note that the functional formulation of a principle includes the possibility of the multiple-choice solutions and a selection from them the best of modifying of definite terms.

Let us give a few examples from the author as an illustration of this methodology for the alternative principles.

- The principle of governance constructions is defined as an alternative to the traditional uncontrolled constructions, which increases their efficiency and reliability, including, by the use and transformation, a part of energy of the external negative impact, as well as redistribution of the internal energy of deformation.
- The principle of construction on weak soils, an alternative which is supposed to use load-bearing properties of weak soils without pre-amplification with the help of a special technique.
- The principle of improving earthquake resistance of buildings and constructions with the help of external seismoprotection which is traditionally not provided.

- The modification of the well-known cybernetic postulate specifying in expediency of the perfection post-learning (improvement on the basis of new information) structure of the system in terms of the incoming current information.

This is the example of the results of search. Yet, the traditional principle (approach) is known. It is necessary to understand and identify the basic cause of the restrictions (hypothesis) which is based on this traditional approach (principle).

Thereafter, is not difficult to formulate the alternative principle which excludes this practice. (This is the answer to the first question: “What do I want?”).

For example, the standard traditional approach of construction on weak soils based on the amplification of weak soils in different specific ways, i.e. natural carrier properties of this soil are not used (but overcome). The required alternative principle proclaims that its usage so is not significant, but natural load-bearing properties of soil («This is the answer to the question: “What do I want?”»). It is possible to imagine the well-known example: you can not successfully go on virgin snow in the traditional shoes, but you can find another way (for example, skis). This is the answer to the following question: “How to do this?”, i.e. give rise to inventions, and perhaps in different forms.

3. The essence of the system algorithm of creative thinking (SACT)

Creative activity is based on the system approach, on regularities of functioning, evolution of systems and diverse methods of decision-making. The scheme of the algorithm of creative thinking (SACT) is represented in Fig. 1.

The aim of the creative (rational) thinking is to find (give) the solution of a problem based on

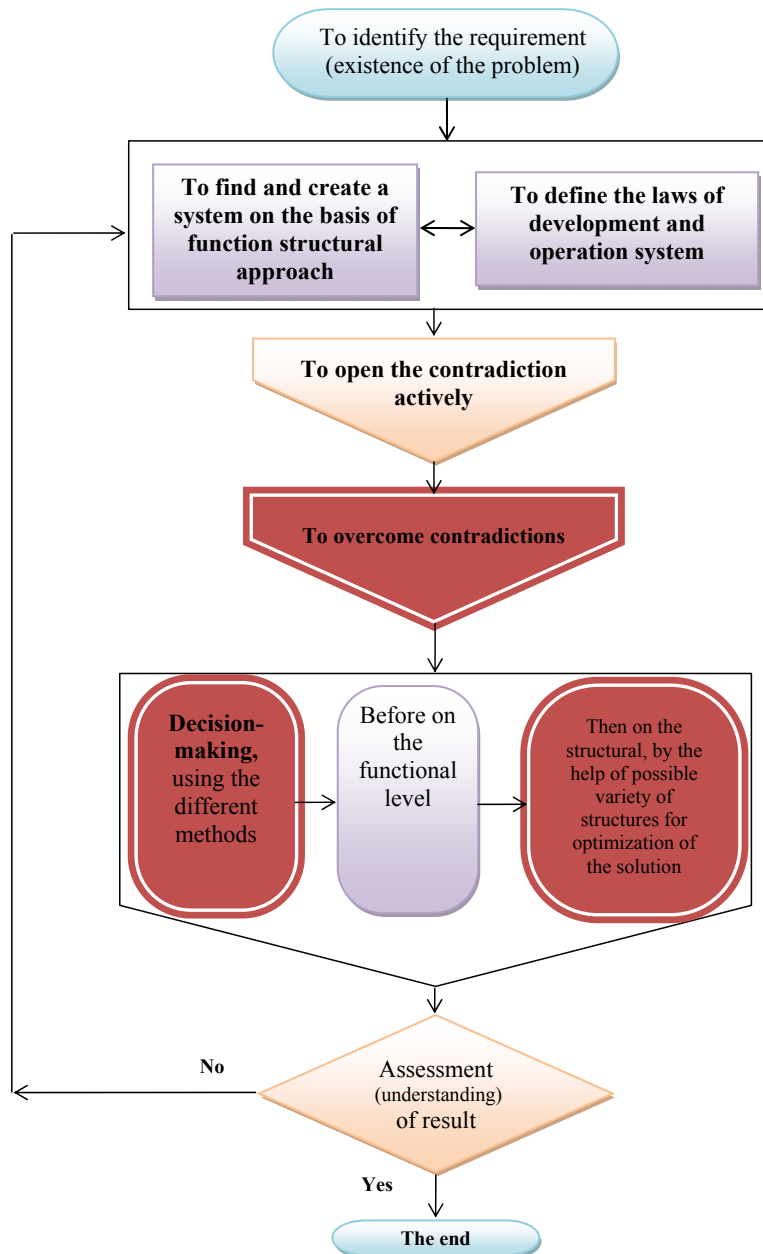


Fig 1 The system algorithm of creative thinking (SACT)

a certain requirement, according to the operating regularities and the terms of this system focused on achievement of the desired purpose. For the starting point we take the formulated alternative principle, which provides the creative search of its constructive realization with the help of SACT. We will allocate the basic stages of this creative search.

3.1. At the first investigation phase it is necessary to find out if this requirement was earlier satisfied, therefore it is necessary to study the previous system: its integrity, elements, connections, restrictions, interaction with environment, its functionality and presence of the contradictions, unused resources, to choose and prove criterion of an estimation of the result (old

and wanted), to analyze from a position over – system (the expanded system). It is necessary to define the system; within a framework it is possible to solve this problem. The choice of such a system is the major key factor. Its choice is usually carried out at intuitive level, in the certain vision (guess), and does not reduce itself, as a rule, to formalization.

In many problems the choice of the system is contained in the required data in the formulation of the problem. It is clear that unfortunately or incorrectly selected system does not allow coming to a rational decision.

When building a system it is necessary to make sure that it contains a complete (holistic) a set of functional elements, that connections between these elements are arranged and the functioning of the system gives the desired result.

The absence (or violation) of at least one from these three factors (a complete set of elements and the correct placement of connections for a possible goal achievement) makes the system inadequate, and solution is impossible (irrational). **Thus, we understand complete (holistic) set of functional elements as systems which are linked with each other, so it is possible to achieve the desired goal.** We emphasize that the thesis are given on the level of functional (not structural) elements and connections.

This functional-structural approach a priori provides the possibility of the choice of various structures which satisfy this **functional** system, i.e. the opportunity to choose a rational structure of the set of possible structures is provided at the stage of decision-making.

We note that the system should be formed according to the objective regularities of development (evolution) systems of this type.

For example, the transition from manual to mechanized, and then to the computerized technology, with the help of the more advanced materials and energy sources, etc. The chosen

system is the subject to identification and analysis of the internal regularities of the system and in order to identify conflicts (problems) it is connected with the external environment. It is necessary to identify the most significant major contradictions which impede the successful functioning of the system.

3.2. For the active opening of a contradiction

it is necessary to construct a model of its inputs and outputs, to identify the controlled (variable) and uncontrolled (non-editable) parameters of their connection and subordination, to consider whether it is possible to remove the restrictions or make some uncontrolled parameters controlled, to identify the information, which depends on quality and accuracy of input in order to analyze the influence of the environment on the system, to clarify or change the goals (output). To clarify trends (laws) of development of this subject of the system. To determine the ideal solution.

Finding ways and means **to overcome these contradictions** is the most important stage of thinking. For the technical systems well-known funds of physical effects and new advances of science and technology are used. It is not exception that at this stage it may be necessary to modify the original system (for example, to extend it by introducing additional elements), and then repeat steps 1 and 2. At this stage it is desirable to find such an idea, which has successfully overcome the revealed fundamental contradiction at its core, or contain large “stock of efficiency” which allows spending unimportant 10-15% of the stock and a priori ensuring success. The author was lucky to use this concept in many inventions.

3.3. For decision-making in order to find the contradictions it is advisable to use different methods, including logic, inversion, heuristics, etc.:

- InfoBase, the physical effects;
- New scientific and technological achievements;
- To search for the concept of the system;

- To identify functional modules and to build a functional diagram of the system;
- To develop options for different structural modules and choose the more effective;
- To apply the composite structure, synthesizing the best properties of component materials and their spatial intermutation.

Therefore, based on the choices which are aimed to overcome the contradictions, we can start building the structure, selection of the best options from a variety of possible, using various familiar methods of decision making (brainstorming, etc.). Let us note, that some of these techniques could be used at the previous stages of the algorithm, for example, to select the system.

3.4. The assessment of decision-making completes a series of creative exploration. It is necessary not only to evaluate the effectiveness of the decision, but also to consider the problems which arise after the realization of this decision. It is known that the solution of some problems creates the new ones. **Understanding the results** includes assessment of the consequences of the decision making and the emergence of

new problems, as well as the possibility of generalizations and extensions and setting a new task with a totally new concept. This is facilitated by the identification of the causal connections between input and output; there is a feedback, the impact of output to the input.

If the desired goal is achieved, the process ends. If not, you need to go back to Step 1, make changes (often additions) in the original system and repeat the process at a new stage of search.

4. The principle of creation of the controlled structures, which control their stress strain behavior (CSC SSB)

The controlled constructions unlike the traditional ones – are a new modern stage of development of structures equipped with the control module, with the help of direct and feedback communication, representing the whole automatic control system of stress-deformed state structures (CSC SSB).

SSB control opens up new opportunities for many high-quality constructions.

CSC SSB is created at the crossroads of mechanics, cybernetics, the theory of automatic

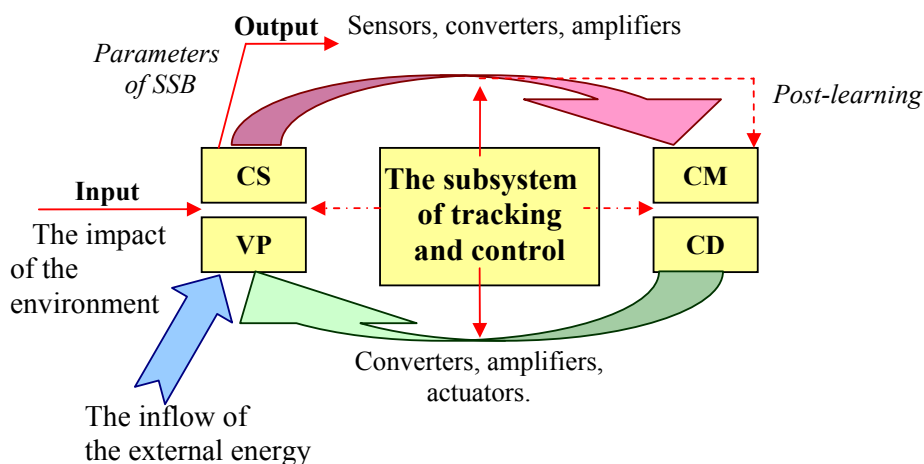


Fig. 2. The functional scheme of the CSC SSB – controlled structures; VP – variable parameters, CM – controlling module; CD – controlling decision

control, electronics, applied mathematics, programming, neuroinformatics and other fields of science and technology.

Academician Igor F. Obraztsov, Head of Mechanics and Control Systems Department of RAS, wrote: “Undoubted priority in the development of the controlled structures and civil engineering structures belongs to the collective of authors of scientific and educational complex “Controlled structures and systems”. The principles, techniques and devices for controlling structures which the team developed are originally performed at the high level and are reflected in a large number of scientific articles, books, teaching aids, laboratory works and inventions.”

In the monograph (Abovskiy, 1998) a series of controlled structures are presented: patents RU 2068918, 2053539, 2073839, 2105959, 2090693, 2087622, 2105853, 2090486, 2050755, 2120515, 2041535, 2069029, 2122188, 55493, 2010345, 1730657.1720065, 1795505, 2012063, 2041727. Series of other controlled structures are presented in this paper, particularly in the energy principle section.

5. The principle of energy approach to the controlled structures (Fig. 3)

5.1. The example of the inventions is based on the conversion of the part of external energy

Requirement: it is necessary to increase efficiency (e.g., weight reduction) and reduce accidents.

System: the traditional building constructions are usually made immutable, without feedback and SSB control.

Contradiction: the energy flux of external influences is considered in the design as a kind of aggression to the maximum resistance that is created by the design. The energy of internal deformation structures should resist external impact of the energy. The contradiction lies in the fact that these processes are generally not considered as a power positions and therefore can not use the methods of transformation and redistribution of this energy for the purpose of improving the efficiency and without defects of construction.

Overcoming contradictions: A part of the external energy (“evil”) can be transformed and

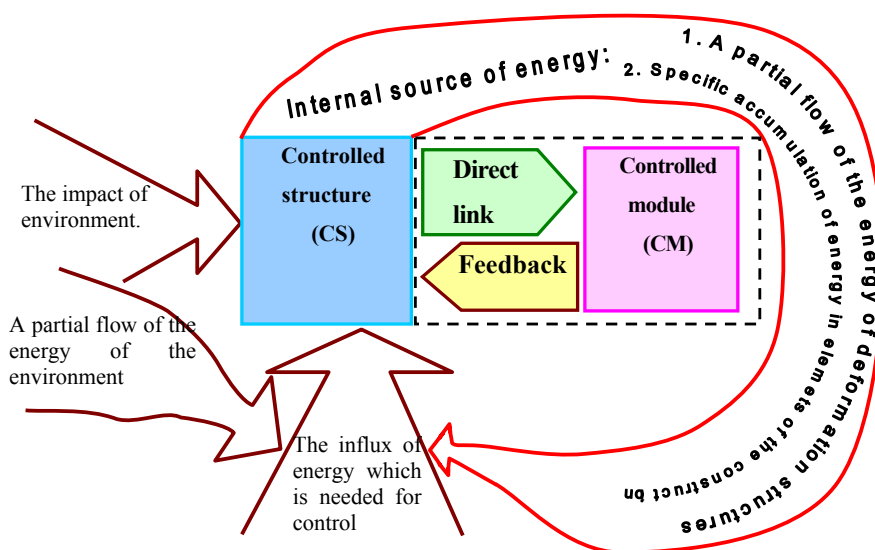


Fig. 3. Energy system of security CSC SSB

used to increase the resistibility of designs, i.e. in “good”.

Decision-making:

1. We select a part of the external energy (for example, wind or water flow, patent RU 2041535, 2069029, 2068918, 2090693, 2050755), it accumulates energy (for example, with the help of a sail), and then with the help of the actuator (for example, the lever) redirect its impact toward resistance.

On such a principle a number of devices are patented for different designs (patent RU 2041535, 2090693, 2105853, 2120515):

Example: the patent RU 2105853. The automatic control the deformation of a high tower consists of a deformed high tower, the trunk which is connected by cables – braces with loads of counterweight situated on sloping sites, attached to anchor the bases, equipped with an automatic control of its deformed state of the wind influence, which is done in the form of sails -webs on mobile towers located on a horizontal platform at the top of the tower. In the land of the instruments there are special whose ends which are connected to the cargo-counterweight, mounted on the ramp. Sail-cloth on the mobile towers are connected by cables to the ends of the special levers at the opposite end on which there are loads, counterweights are connected with cables, braces, the other ends are attached to the stem of the tower under the ramp.

For example, for buildings (structures) such an order of assembly is used, i.e. gradual loading of its own weight or additional weight is a partial unloading of what previously assembled [patent RU 2105853, 2090693].

5.2. An example of the energy approach to engineering

By the transformation and redistribution of the internal strain energy

Requirement: to increase the efficiency of designs.

Contradiction: The internal energy resistance of the deformation in the construction of its parts distributed unevenly. The separate parts (section) unload, while others remain intact. **Overcoming contradictions:** there is an expediency to distribute and redirect internal power streams in more dangerous places, having selected a part of energy from other less dangerous places.

Decision-making:

The redistribution of energy can be done with a lever and a block device, reinforcing the dangerous places [the patent RU 2068918] either to increase rigidity or to reduce the amplitude of the oscillations.

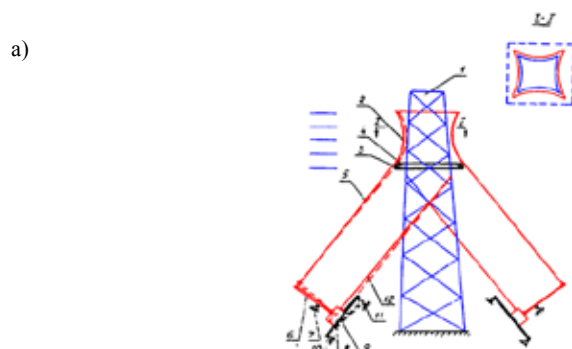
5.2.2. About equally strong constructions.

In some cases it is useful to «equalize» voltage in the dangerous sections closed the design to equal strength, i.e. for example, you need to create a device which ensures the creation of the balancing process. There are many processes which seek to equalize the potentials of equilibration in nature (e.g., with the help of the Wheatstone electric circuit, communicating vessels, etc.). If you combine design with the similar equilibrium processes, you will achieve the result automatically (RU patent with Wheatstone bridge № 2010345) (Fig. 5).

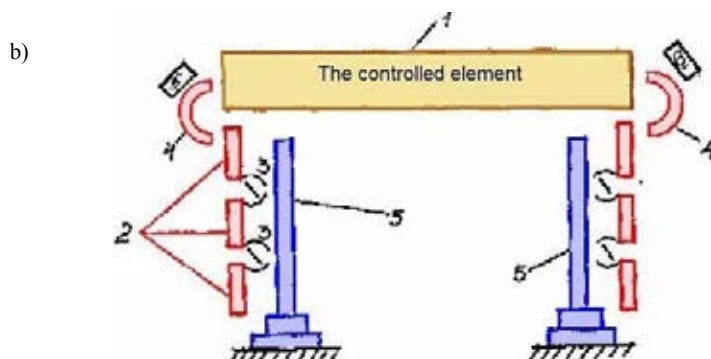
If you note the invention is based on rather general principles, with the help of this approach we will extend a series of specific inventions.

6. The principle of construction in difficult soil conditions and seismic regions

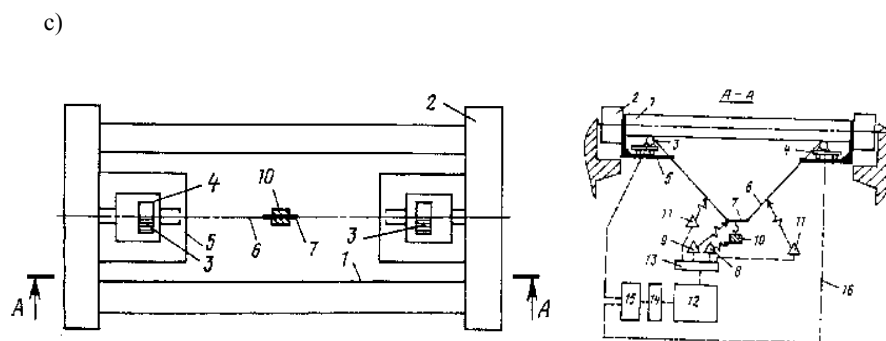
There is considerable uncertainty concerning external influences which is a feature of this inventive theme (e.g., possible subsidence



Patent RU 2105853 The device of automatic control deformation high tower



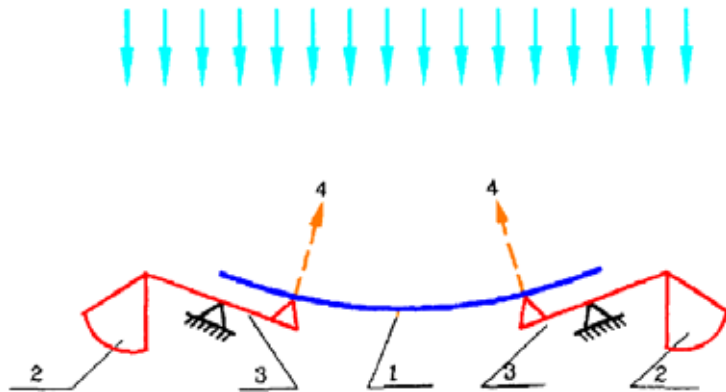
Patent RU 2068918 The control method of building constructions



patent RU 2090486 Automatic control of SSB crane

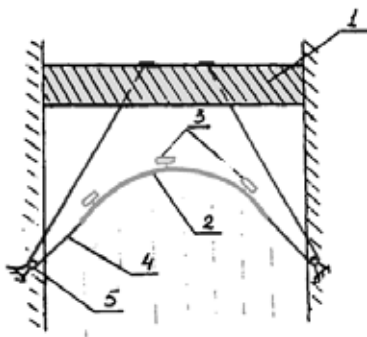
Fig. 4. Control of building structures: a) Patent RU 2105853 The device of automatic control deformation high tower; b) Patent RU 2068918 The control method of building constructions; c) patent RU 2090486 Automatic control of SSB crane

d)

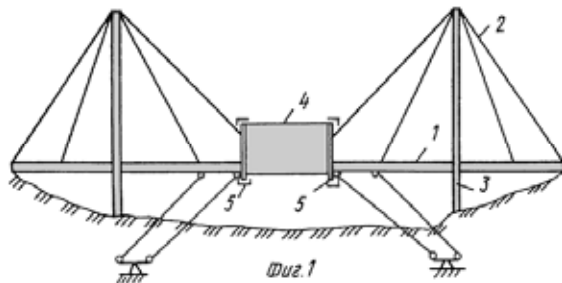


Patent RU 2041535 The prevention method of deformation of the mirror (surface) of the antenna

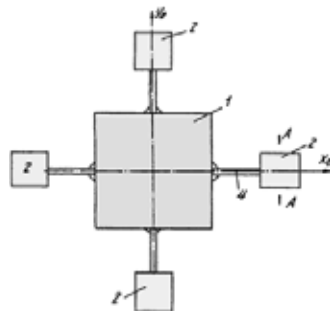
e)



f)



g)



Patent RU 2087622

The seismo-stable building and construction

Fig. 4. Control of building structures: d) Patent RU 2041535 The prevention method of deformation of the mirror (surface) of the antenna; e) patent RU 2090693 Automatic protection of the dam; f) Patent RU 2120515 The device of bridge protection from crosswinds; g) Patent RU 2087622 The seismo-stable building and construction

and deformation of the uneven soils and their parameters, and also values of seismic load, the theory of lag, etc.). This problem is not solved by “at the head”, but you need to build. The bypass principle of solving these problems is proposed, it involves creation of insensitive design to such negative uncertain conditions.

Such a way led to the creation of spatial foundation platforms (SFP) for the construction in the complex soil conditions and seismic activity (Abovskiy, 2009), which is an implementation of the principle used for the construction of the natural load-bearing properties of the weak soils without their specific amplification, which allows to preserve the environment of the land and subsurface environments. This principle is alternative to the existing traditional approach to the Foundation Engineering on weak soils which is spelled out by standards which either prohibit construction, or regulate their gain by special means. In order to implement the proposed principle, the SFP and their various design solutions, including weak soils in seismic regions are developed. It may seem that this approach is not economical for the material consumption, so it does not correspond (contrary to) the traditional solutions which focus on the maximum (limit) use of load-bearing properties of soils (Fig 6). This traditional economic approach to the design of the foundations does

not meet the economic system assessment of the whole building with the foundation, including the cost of not only construction, but also the cost of its use.

Example 1.

The requirement for the effective solution of this problem is obvious, there are many “inconvenient” acres, and we must build efficiently, reliably and inexpensive.

Contradictions: there are methods which tend to focus on amplification of the weak soils or neglect their load-bearing properties (e.g., by the use of the pile foundations) and adaptations of traditional basic designs to these frameworks.

Overcoming contradictions: the creation of solid spatial foundation platforms (SFP), which would possess a great ability to transfer the load distribution on the soil, use the weak properties of soils (without amplification), and be insensitive to their possible differential sediments (subsidence).

Examples of analogies:

1. In order to walk on snow a man is not engaged in compressing the snow and creates a structure of skis;
2. A special form of the ship is created on water.

Decision-making:

SFP is shaped from the system of intersecting top and bottom plates, connected



Fig. 5. Automatic control of the stress-strain behavior of truss beam (patent RU 2010345)

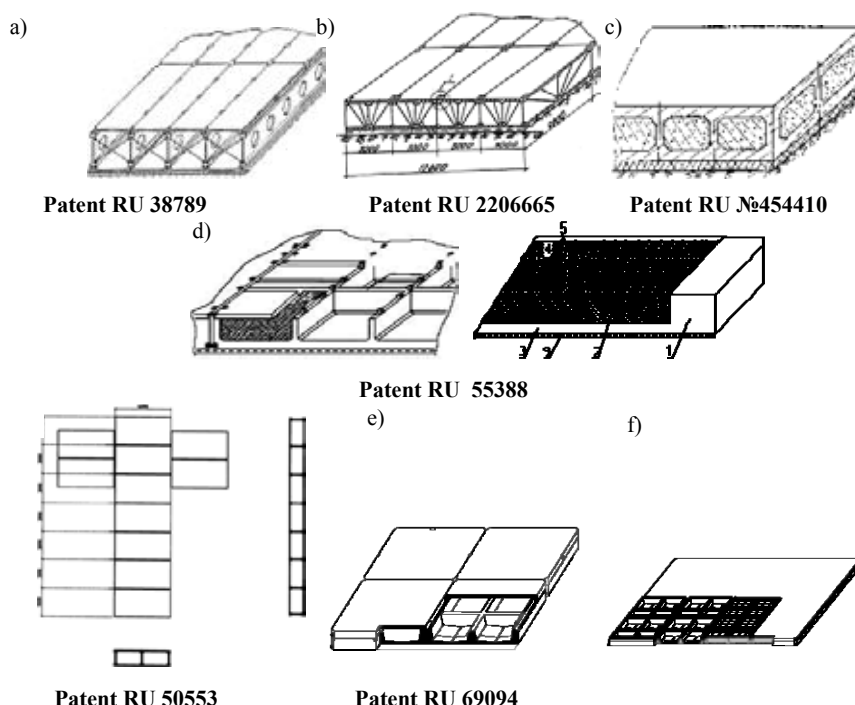


Fig. 6. Spatial foundation platform for building the weak and permafrost soils: a) precast reinforced-concrete platform (patent RU 38789); b) precast reinforced-concrete foundation platform (patent RU 2206665); c) Monolithic base platform (patent RU 454410); d) precast and monolithic variants (patent RU 55388); e) spatial foundation platform under aggregate with a dynamic load (patent RU 50553); f) spatial reinforced-concrete in precast and precast-monolithic variants (patent RU 69094)

by the system of ribs reinforced concrete beams, which increase stiffness in the effective material consumption.

The interior space of SFP is used to combine functions: for warmth, for equipment or ventilated underground, and the outer surface of the SFP is load-bearing floor.

The upper structure is connected with the SFP in the whole closed structure (system) to increase the rigidity.

Multivariate solutions: developed and patented monolithic, precast and precast-monolithic SFP [patent RU 38 789, 45 450, 50 553, 2273697, 2206665, 55 388, 64 650, also for buildings and facilities [patent RU 22115852, 29 738, 53 342, 59 650, 63 375]. (Fig. 7 and 8)

For example: patent number 45 410. Monolithic spatial base platform is made of two

thin reinforced concrete foundation plates which are arranged one above the other, monolithically bonded together by the cross reinforced concrete beams. The space between the cross-reinforced concrete beams is filled with such insulation as the expanded clay. A sliding layer of the material with a low coefficient of friction is placed between spatial monolithic foundation slab and the base. The development of these patents were designed and patented for closed-building and structures and tanks, which are combined with the spatial platforms [patent RU 2215852, 29 738, 59 650, 63 375] (Fig. 7 and 8).

Example: The patent RU 59650. Seismic low-rise building, the structure includes topsides and foundations, which are connected by solidly constructive ties into a coherent closed system in a type of box or a cage space. The foundation is

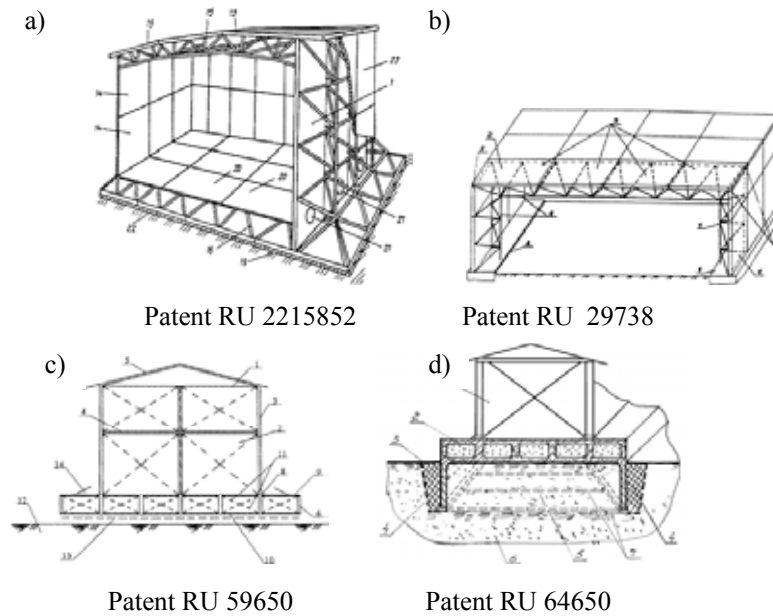


Fig. 7. a) complete – precast building and construction of a closed type (patent RU 2215852); b) complete - precast building from steel reinforced-concrete elements (patent RU 29738); c) the seismic low-rise building, structure (patent RU 59650); d) spatial foundation platform under\for building and construction (patent RU 64650)

designed as a solid foundation spatial platform which is recessed of soil, consisting of upper and lower panels, fastened together by the cross beams, between which there is emptiness, the space between them is filled with such an insulation as the expanded clay. The upper panels are aligned with the floor of the first storey. The sliding layer is arranged between the spatial platform and the leveled base, which is made, for example, of several layers of polymer film such as polyethylene, with powder inert material.

Example 2.

Here is an example of application of this algorithm for creating of the earthquake-proof structures. There is a need to construct buildings in seismic regions. This system consists of the upper structure and the foundation and base, which produces an effect on the seismic wave. Further, this seismic impact applies to the upper structure, which may cause deformation and possible collapse. The damping device is used in typical designs to reduce the seismic impact on

the upper structure between the foundation and the upper structure.

The contradiction between the base and foundation is base, which should take the load from the foundation and report to the foundation of a negative horizontal seismic effect. In addition, the location of the damping device between the foundation and the upper structure breaks the integrity of the entire structure, affects the strength and deformability because it divides it into parts.

Overcoming contradictions:

To insulate basement from the seismic impact and to ensure the integrity of the structure (the foundation and the upper structure). Ideally, when the foundation is isolated from the base and the upper structure, the seismic effect is not available. For the practical constructive implementation a sliding layer with a low coefficient of friction is placed between the base and foundation (in the form of a solid foundation platform), so that transmission of horizontal

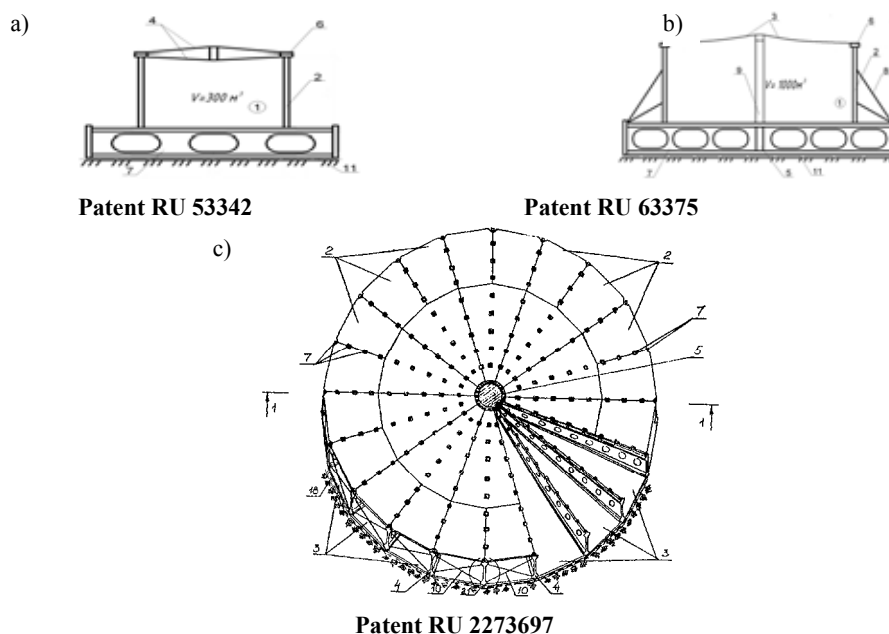


Fig 8. a) vertical precast vessel (Patent RU 53342); b) the recovery of the metal vessel (Patent RU 63375); c) Patent RU 2273697 spatial foundation platform, combined with the vessel in closed structure

seismic impact from the base to foundation is limited. This upper structure is connected to the foundation increasing the whole system.

The solution is founded in the idea, which overcomes the contradiction and constructive decisions and shown in the figures 4 and 6.

The assessment of the results – the goal is achieved and implemented in the patents RU 2068918, 2053539, 2073839, 2105959, 2090693, 2087622, 2105853, 2090486, 2050755, 2120515, 2041535, 2069029, 2122188, 55493, 2010345, 1730657, 1720065, 1795505, 2012063, 2041727.

7. The principle of creating designs which preserve the environment of the northern regions of Siberia

Requirement: For the reclamation of the Siberian territory we need to save the land cover for tundra and permafrost soil.

Contradiction:

The traditional deep foundations (or pipelines) are not acceptable for the environmental

requirements and durability. In addition, for example, the subsequent dismantling of pipelines is very costly. Pile foundations will not come up with the expectations.

Overcoming contradictions: Foundations must be superficial without deepening, prohibiting any thawing of soil and must be insensitive to non-uniform deformation.

Decision-making:

1. The use of continuous over ground space foundations (SFP) with ventilated underground to buildings and structures. Patent RU 38789, 45410, 2206665, 50553, 55388, 2273697, 64650, 2007116526], including tanks [patent number 53342, 63375, 2273697] (Fig. 7, 8).

2. Mobile adjustable legs are used for laying underground pipelines, which are combined with the base plate [RU patents № 2246657, 41 829, 49 251, 53 008, 60 669] (Fig. 9).

The mobile base, which is combined with the base-plates under the above-ground pipelines of various diameters, for the construction of a

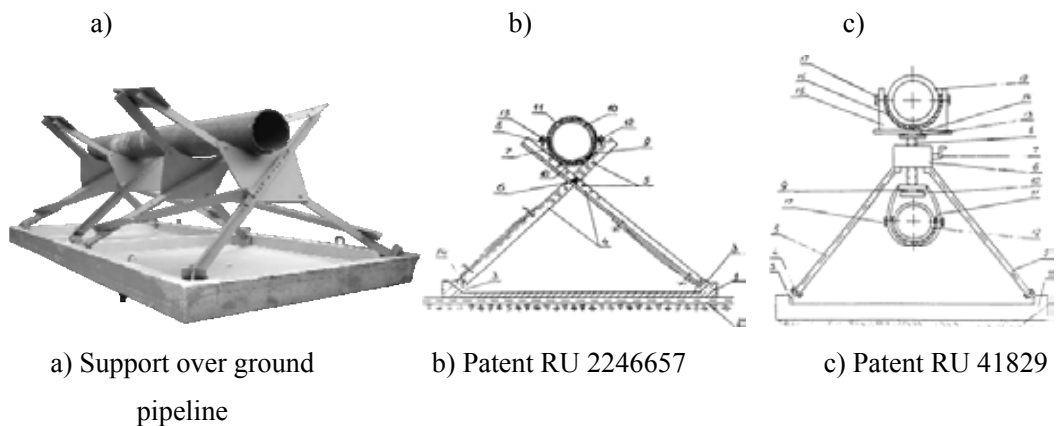


Fig. 9. Supports of over ground pipeline: a) the pattern of regulated support; b) Support over ground pipeline, Patent RU 2246657; c) the regulated support of over ground pipeline, Patent RU 41829

complex soil conditions with adjustable height setting do not require excavation, pile driving, etc.

8. The principle of the systematic approach to the elimination of the unwanted noise

It is widely known that there are different kinds of noise caused by mechanical deformation in various instruments and devices, such as radio (by heat, pressure, etc.). We often make decisions about improving the output and other radio engineering parameters to overcome these distributions, i.e., the causes of the mechanical nature affect devices of a different nature. This non-systemic approach increases costs and reduces efficiency. An example of such an inventive solution is to stabilize the solution by mechanical means (on the basis of the automatic control) of the antenna of the parabolic shape from the wind effects [patent RU 2041535, 2050755].

9. Modification of the cybernetic principle of the control system

We know the approach to the control by H. Winner, which is based on generalization of the previous information. It is fair and efficient, but

it secretly contains a constraint about the role of the current information for the system structure. The removal of this restriction (contradiction about the loss of connection between the systems' structure and the current information) is achieved by further studying (improvement on the basis of new information) of the system (improving it) on the basis of the incoming current information, for example, with the help of the neural network technology. This modernization of the cybernetic principle is implemented, for example, in the method of the incremental neural network forecasting and in the neural traffic lights for the traffic control.

Conclusion

Some new trends and principles in the field of construction and multivariate examples which are implemented in the engineering decisions, based on the proposed methodology of the system creative search of the innovative solutions from the general to specific, aimed at identification and overcoming the contradictions and limitations of the traditional approaches have been developed.

It is advisable to use this methodology in the other areas of technology.

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Принципы, порождающие инновационные конструкторские решения

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Предложены принципы, на основе которых получены с помощью разработанного системного алгоритма творческого мышления инновационные конструкторские разработки. Данная методология позволила открыть и разработать несколько новых направлений научного развития в области строительства:

- *управления конструкциями, включая энергетические аспекты реализации;*
- *строительство в сложных грунтовых условиях и сейсмичности;*
- *экологическое сохранение северных земель Сибири при строительном освоении богатств;*
- *откорректировать известный кибернетический постулат, раскрывающий связь структуры системы и поступающей текущей информации.*

Все эти направления получили инновационную конструктивную реализацию в виде серии патентов некоторых объектов строительства. Пользуясь классическими понятиями творческого мышления, можно определить разработанную методологию как путь от общего (функционального) решения к многообразию частных (конкретных) решений. Эта методология принципиально отличается от известных подходов, в частности теории решения изобретательских задач (ТРИЗ) и различных методов принятия решений, которые ориентированы на поиск конкретных частных решений. Данная методология может быть полезна не только в области строительства, но и в других сферах техники.

Ключевые слова: принципы, системный подход, инновационные конструкторские решения.
